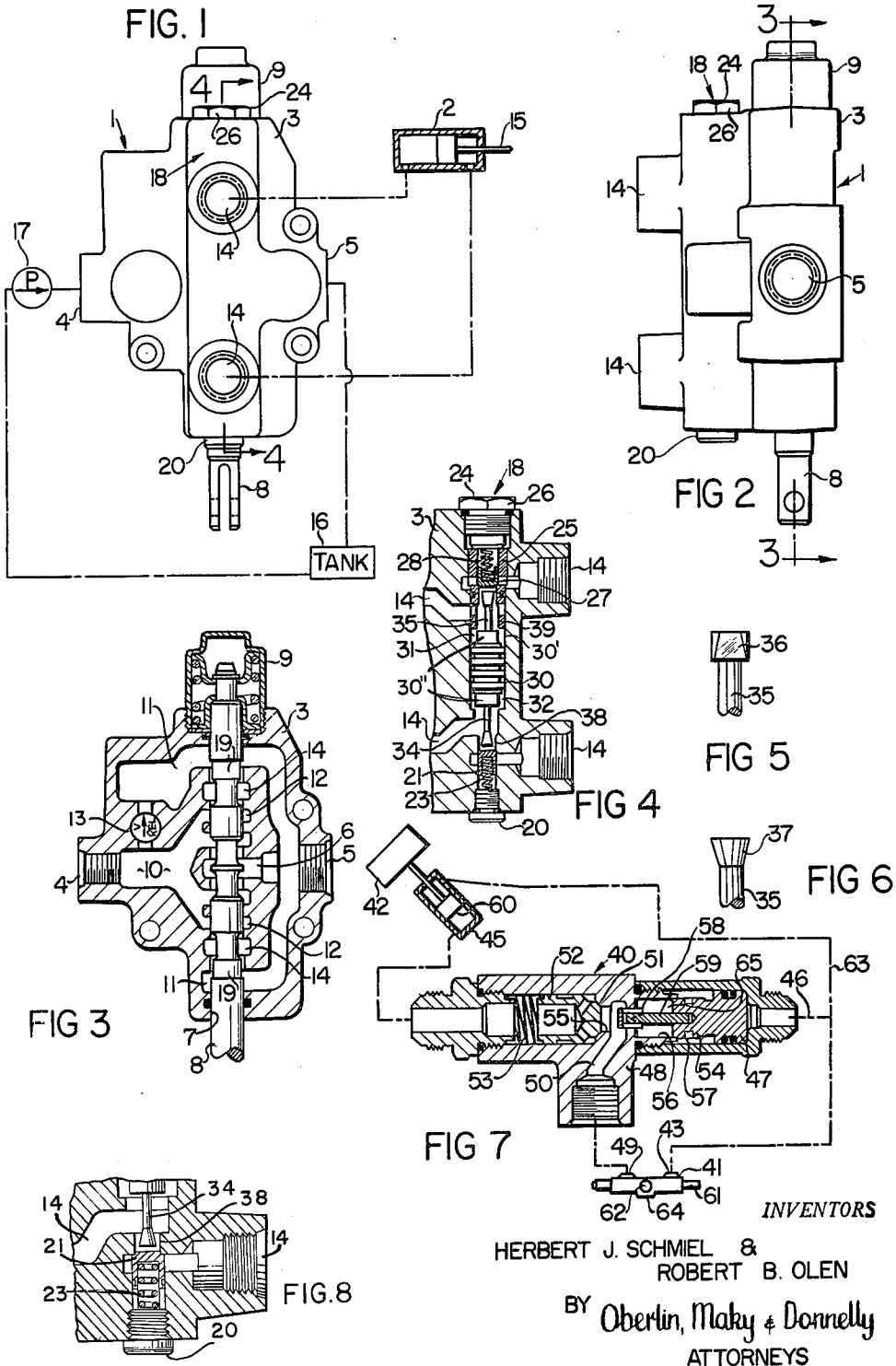


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PRESSURE RESPONSIVE FLOW CONTROL VALVE FOR
DIRECTIONAL CONTROL VALVE
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PRESSURE RESPONSIVE FLOW CONTROL VALVE FOR DIRECTIONAL CONTROL VALVE

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The present invention relates generally as indicated to a pressure responsive flow control valve for a directional control valve and more particularly to a fluid power system having a fluid motor and a pilot operated control which is effective to lock the movable component of the motor against movement and to regulate the flow of fluid during the movement of said component.

In the case of directional control valves for hydraulic power cylinders it is conventional practice simply to provide conduits interconnecting the ports of the directional control valve and the actuating cylinder and to provide metering slots in said valve which, by gradual actuation of said valve, results in smooth acceleration and deceleration of the piston in said cylinder. However, operators of front end loaders, power shovels, cranes, etc. are prone to shift the directional control valves directly to selected operating positions with consequent shocks on the scoops, buckets, booms, etc. that are actuated by the associated power cylinders. Moreover, in systems wherein negative loads are imposed on the power cylinders e.g. power lowering of booms having loaded buckets, it is desirable to limit the speed of movement of the piston so as to avoid severe shock when the movement of the load is arrested by shifting the directional control valve to off or neutral position, or by the load engaging a positive stop position, or by the piston reaching the end of its stroke.

Furthermore, spool-type directional control valves are in prevalent use and since the spools thereof are axial sliding fits in cylindrical bores of the valve housing, they are not fluid-tight and, therefore, when the spool is in neutral or off position, the piston in the power cylinder may gradually creep under the influence of a load thereon due to leakage of the fluid between the spool and its bore.

Accordingly, it is a principal object of this invention to provide, in a fluid circuit between a spool valve and a power cylinder, a fluid-tight valve assembly which will prevent displacement of fluid from the cylinder thereby to lock the piston therein. In the case of a double acting spool and double acting power cylinder, duplicate valve assemblies may be provided to prevent displacement of fluid from both ends of the cylinder, and consequently, the piston therein will be positively locked against movement in either direction when the double acting directional control valve is in off or neutral position.

It is another object of this invention to provide a fluid pressure responsive valve for a directional control valve of the character indicated which has an associated dash-pot effective to meter the fluid to or from the power cylinder for desired rate of acceleration of the actuation thereof, despite the fact that the directional control valve may have been shifted to full flow position.

It is another object of this invention to provide a fluid power system in which a flow control valve interposed between the directional control valve and the power cylinder is effective to limit the speed of actuation of the latter as when the load on the cylinder is negative and of great magnitude.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related

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ends, the invention, then, comprises the features herein-after fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of a few of the various ways in which the principle of the invention may be employed.

In said annexed drawings:

FIG. 1 is a front elevation view of one embodiment of this invention;

FIG. 2 is a side elevation view as viewed from the right of FIG. 1;

FIG. 3 is a cross-section view taken substantially along line 3—3, FIG. 2;

FIG. 4 is a fragmentary cross-section taken substantially along line 4—4, FIG. 1;

FIGS. 5 and 6 are side elevation views of two forms of flow control valve elements;

FIG. 7 is a cross-section view of another embodiment of this invention; and

FIG. 8 is an enlarged fragmentary cross-section view of the lower valve assembly of FIG. 4.

Referring now more particularly to the drawings, and first to the form of the invention illustrated in FIGS. 1 to 6, the directional control valve 1 for the double acting power cylinder 2 comprises a housing 3 having a pressure inlet port 4 which communicates with the tank return port 5 by way of a bypass passage 6 intersecting the bore 7 in which the double acting spool 8 is axially slidable, the spool 8 having connected at one end thereof a spring return mechanism 9 which automatically restores the spool to neutral or off position (see FIG. 3) from either of its operating positions when axial force on the spool 8 is released. A relief valve 13 in housing 3 limits the pressure in the inlet chamber 10, excess pressure being relieved to the tank port 5 via return passage 11.

The inlet chamber 10 leads to a pair of feed passages 12; 12 intersecting the spool bore 7, and straddling the feed passages 12; 12 are the service ports 14; 14 which, as shown in FIG. 1, are adapted to be connected to the ports at the ends of the power cylinder 2.

The spool 8 herein shown by way of example is of the double acting type having alternate lands and grooves arranged so that, upon axial movement of the spool 8 from the neutral position shown in FIG. 3, fluid under pressure passes from one feed passage 12 into the adjacent service port 14 to actuate the piston 15 in the cylinder 2 in one direction and the fluid displaced from the other end of the cylinder 2 flows through return port 5 to a fluid reservoir 16 via the other service port 14 and the adjoining return passage 11.

The directional control valve structure thus far described is more or less conventional and well-known in the art. When the spool 8 is returned from one operating position to neutral by spring mechanism 9, the fluid delivered by the system pump 17 to the inlet port 4 freely passes through the housing 3 to the return port 5 via the aforesaid bypass passage 6 and usually the spool 8 will have lands blocking the service ports 14. However, spool valves cannot be made fluid-tight except at great expense either by extremity fine machining or by employing rubber-like sealing rings.

In the present case, in view of the provision of the pressure responsive flow control and piston locking valve assembly 18 it is not required in the neutral position to try to completely close off communication between the service ports 14 and the return passages 11 and thus the spool 8 herein is formed with land portions 19 of substantially smaller diameter than the spool bore 7.

The pressure responsive flow control 18 is embodied in the same housing 3 as the spool 8. For a double acting spool 8, it is preferred to employ duplicate valve as-

semblies disposed in the respective service ports 14. As best shown in FIG. 4, one valve assembly 20 comprises a valve member 21 held by spring 23 in position closing the lower service passage 14. The other valve assembly 24 associated with the upper service port 14 comprises a tubular valve body 25 held in place by a plug 26 threaded into the housing 3 and having a seat against which the valve member 27 is pressed by the spring 28.

The valve members 21 and 27 are, as shown, in coaxial alignment and between them is a pressure actuated plunger 30 which is slidably received in a cylinder 30' interconnecting the upper and lower service ports 14, 14. The plunger 30 has a cylindrical extension 30'' on each end thereof, the upper extension being adapted to cooperate with a bushing 39 disposed in the cylinder 30' to form a dashpot 31 as the plunger moves up, and the lower extension being adapted to cooperate with the walls of the adjacent service port 14 to form a dashpot 32 when the plunger moves down. The plunger 30 also has opposite coaxial extensions 34 and 35 adapted to engage the respective valve members 21 and 27 to unseat them. The ends of said extensions 34 and 35 are preferably of about the same diameters as the bores into which they extend, except for tapering flats 36 on opposite sides as clearly shown in FIG. 5, whereby, as will be seen hereafter, these heads or ends of extensions 34 and 35 serve as metering or flow control means, depending on the extent of movement of the plunger 30.

If desired, the metering heads of the plunger extensions 35 may be frusto-conical, as shown at 37 in FIG. 6.

Insofar as operation is concerned, assuming that the spool 8 is in neutral position (FIG. 3), the spring-seated valve members 21 and 27 will preclude displacement of fluid from either end of the power cylinder 2, whereby a load on the piston 15 in either direction will not cause movement thereof from its thus locked position. Now, supposing the spool 8 is moved downwardly from its FIG. 3 neutral position, it can be seen that fluid under pressure will flow from the upper feed passage 12 into the upper service port 14 and as the pressure builds up in the service passage 14, it acts downwardly on the area of the plunger 30 to force the lower valve member 21 away from its seat, whereas the upper valve member 27 will act as a check valve to permit flow of fluid from the upper service port 14 into the head end of the cylinder 2. The piston 15 therefore moves toward the right and the fluid displaced from the rod end of the cylinder 2 passes through the lower service port 14, through the open valve member 21 into the lower service port 14 and thence into the return passage 11. The dashpot 32 permits only controlled slow movement of plunger 30 whereby the return fluid is metered past the tapered sides 36 or 37 of the extension 34 until the neck of extension 34 is in bore portion 38. The inlet fluid is also metered past the tapered sides 36 or 37 of the extension 35 until the head reaches the enlarged bore portion of the bushing 39 in body 25.

Should the load on the piston 15 change from positive to negative with consequent drop in the pressure acting on the upper side of the plunger 30, and with an increase in the pressure in the return circuit acting on the lower side of the plunger 30, the plunger 30 may move upward to decrease the inlet and return flow past the upper and lower metering heads. Therefore, the piston 15 will be precluded from moving too fast under the influence of such negative load.

Of course, when the double acting spool 8 is shifted upwardly from the FIG. 3 neutral position, the piston 15 in the cylinder 2 will be caused to move toward the left with incoming fluid flowing past the lower valve member 21 which is then functioning as a check valve and the returning fluid flows past the upper valve member 27, which is now moved away from its seat by the upward movement of the plunger 30 with its extension 35 engaging and moving the upper valve member 27 away from

its seat. The dashpot 31 and the metering heads of extensions 34 and 35 are effective to meter inlet and return flow in the same way as explained above.

In FIG. 7 is shown an embodiment of the invention employing a pilot operated lock flow control 40 which is separate of the double acting spool valve 41. Since, in this embodiment, for example, the tilt control of a boom of a front end loader, or the like, has only a downward load 42 on the piston there is no need for duplicate fluid pressure responsive flow controls as in the case of FIGS. 1 to 6.

In this case, the directional control valve 41 has one service port 43 connected to the upper rod end of the power cylinder 45 with a branch 46 leading to one side of a plunger 47 reciprocable in the body 48 of the pilot operated flow control valve 40. The other service port 49 of the directional control valve 41 is connected to the head end of the cylinder 45 via a passage 50 through the body 48. The aforesaid passage 50 is formed with a seat 51 engaged by the valve member 52 biased by spring 53. In this case, the plunger 47 has an extension 54 which projects into the passage 56, there being a slight clearance between the extension 54 and the walls of the passage 56 to define a dashpot 57. Head 58 of extension 59 has V-shaped metering slots as shown to control flow according to the axial position of the metering head 58 in bore 55. The end of the metering head 58 is adapted to engage the valve member 52 to force it away from its seat 51.

Assuming now that it is desired to raise the piston 60 in the cylinder 45 to raise the load 42, or to tilt the aforesaid boom upwardly, the directional control valve spool 61 will be shifted to communicate the left service port 49 with the inlet 62 and thus the pressure will unseat the valve member 52 so that fluid may flow into the head end of the cylinder 45. The fluid displaced from the rod end of the cylinder 45 passes through the conduit 63 into the right service port 43 which then is in communication with the return port 64.

Now, if it is desired to lower the piston 60 and thus the load 42 thereon, the directional control valve 41 is actuated to communicate the inlet port 62 with the right service port 43 in which case fluid under pressure is delivered into the rod end of the cylinder 45 and the fluid displaced from the cylinder 45 will pass through the valve member 52 which is gradually opened by the slowly moving plunger 47 to the left service port 49 which is in communication with the return port 64. If the descent of the piston 60 and load 42 is more rapid than desired, the pressure acting on the end of the plunger 47 may decrease to the extent that the pressure drop across valve member 52 is sufficient to move the latter and also plunger 47 toward the right whereby the metering head 58 in bore 55 effects throttling of the return flow and consequent decrease in the speed of descent of the piston 60. The dashpot 57, including dashpot 65, assures desired slow and gradual movements of plunger 47 in opposite directions to avoid shocks in the system.

In addition to, or in lieu of, the dashpots 31 and 32 aforesaid, the spring chambers behind the valve members 21 and 27 may constitute dashpots when said members are slide fits in their respective bores, as perhaps best seen in FIG. 8. Thus, the plunger 30 can only move at a slow rate to provide the desired metering action.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

We therefore particularly point out and distinctly claim as our invention:

1. A flow control valve comprising a body having a pair of passages; valve members in the respective passages; springs biasing said valve members to positions closing the respective passages; said body having a cyl-

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inder therein in fluid communication with said passages upstream of said valve members; a plunger in said cylinder having one end exposed to fluid under pressure in one of said passages and the other end exposed to fluid under pressure in the other of said passages; said plunger being adapted to be moved by predominant fluid pressure in either passage into engagement with the valve member in the other passage to move it to a position opening said other passage; said plunger having flow metering means on either end thereof which are operative simultaneously to meter the flow through both of said passages when one of said passages is opened by engagement of said plunger with its respective valve member, and the other of said passages is opened by fluid pressure exerted on its respective valve member.

2. The flow control valve of claim 1 wherein said plunger end portions are tapered.

3. The flow control valve of claim 1 wherein said plunger end portions have tapered sides to define segmental flow passages.

4. The flow control valve of claim 1 wherein said plunger end portions are of frusto-conical form.

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